DOCUMENT RESUME

ED 420 626 SP 037 985

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TITLE Bridging the Gap between Theory and Practice: Fostering Active Learning through the Case Method.
PUB DATE 1998-01-00
NOTE 23p.; Paper presented at the Annual Meeting of the Association of American Colleges and Universities (AAC&U) (84th, Washington, DC, January 15-17, 1998).
PUB TYPE Reports - General (140) -- Speeches/Meeting Papers (150)
EDRS PRICE EDRS Price MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Case Method (Teaching Technique); Elementary Secondary Education; Higher Education; *Inquiry; Preservice Teacher Education; Science Education; Scientific Methodology; Student Teachers; Teaching Methods; Thinking Skills

ABSTRACT

For years, the case study approach to learning has helped connect formal learning with real life situations. Cases offer a means of combining the content to be taught and processes by which it will be taught, and it provides students with a situation for learning that makes sense to them and connects them to what they know in a meaningful way. The pedagogic philosophy used in the case study approach is bound by the belief that learning is primarily a self-acquired process. The case method is learner-centered, relying on students' experiences to collect, interpret, and explain circumstances presented in the case. The case method provides learners with facts and parameters of a particular event and asks them to examine possible interpretations and investigate approaches to what is happening. The case method effectively enhances learning because it: (1) develops higher order thinking skills, (2) illustrates the relevance of the study in society, (3) asks students to question assumptions underlying the theories presented, and (4) shows learning from the cases long after the study concludes. The paper addresses reform effects in scientific teaching and learning by providing a case study that includes both storytelling and an accompanying laboratory. The study was designed using a rubric of criteria that emerged from the literature on case method and scientific learning. (Contains 11 references.) (SM)

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ED 420 626

"Bridging the Gap between Theory and Practice: Fostering Active Learning through the Case Method"

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Presented at 84th Annual Meeting of AAC&U Washington, D.C. January, 1998

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"Bridging the Gap between Theory and Practice:

Fostering Active Learning through the Case Method"

Introduction and Background

For many years the case study approach to learning has been used to connect formal learning with real life situations. The range of pedagogic uses of the case method is vast and the purpose for its use varies greatly. The professional fields in the study of law, medicine, business, and engineering use this approach to hone problem-solving skills by providing students with facts and definitions of situations to which they must predict the outcome. These fields define a problem as any situation, or question which does not have a ready explanation. Cases are developed to portray important problems identified by practitioners as "typical and recurrent in their professional practice" (Broudy, 1990). There is some agreement among those who practice in these profession about a common core of knowledge that needs to be learned in order to solve problems. Lawyers, doctors, and engineers regardless of where they were prepared or where they work are likely to use the same classifications and terms to discuss the problems that emerge in their fields (Broudy, 1990). Students studying in these programs are put in challenging conditions which demand strategies, insightfulness, perseverance and "craftmanships" to resolve the problem presented (Costa). In these professional areas of study, use of the case method brings together theory and research in order to "interpret perennial problems and explore alternative solutions to them" (Broudy, 1990).

Social Science areas such as Anthropology and Psychology use the method to "tell stories" and in turn, provide students with a description of events over time from which they can deduce patterns or themes that tell them more about the situation than a snapshot view or a single

occurrence. Students demonstrate that they can apply theory to a particular situation. Using cases in this way may not invo'ye the actual treatment of a client; it is different than an apprenticeship required for a clinical psychology license or a social work degree. It is a way of assessing the understanding of a student about a situation described as occurring over time.

The field of education has endorsed the use of cases for preparing teachers. In particular, cases are seen as a means of combining the content to be taught and the process (pedagogy) by which it will be taught. The disjuncture between the two has been debated for years. Issues of pedagogy have been seen as the domain of departments of education while issues of content have been firmly grounded in specific subject derived departments. Case approach offers a vehicle for the interaction of the two. Cases cannot be written without a description of the particular situation that involves subject-specific content. "Cases by definition put into the picture the particulars of who is teaching what, to whom, and how" (Hutchins, 1993). Case studies, in a sense, have really come into their own in the area of teacher preparation. In this context, they usually present a narrative of a problem to be solved. The last sentence of the narrative is usually a prompt such as "as she opened her grade book to annotate comments on the morning's activity, she wondered if she would approach the problem differently" (Peterson, 1992, in Silverman, et al, 1992). After the narrative is read, members of the class discuss various ways of dealing with the "problem" and arrive at a desired outcome. This method has evolved into an effective way of preparing students for the teaching profession by providing them "windows" to the issues that need to be talked about and reflected upon.

The use of cases in the more traditional liberal studies areas is more recent. Areas of science, in particular, are beginning to embrace this approach for two reasons: the introductory courses have consisted of a "bewildering" set of seemingly unrelated facts and terminology and

the material often seems uninteresting and irrelevant (Moore, 1988). The standard introductory course offered is often seen by students as something to be endured—it either bores them or scares them. When specific cases are designed around themes the material can be organized to be approachable, meaningful, intellectually rigorous, conceptually based, and relevant to the experiential world of students. The case approach helps students learn more about content and how it relates to the world in which the students live.

All uses of the case method differ according to the educational objectives of the classroom and the philosophy of learning embraced by the instructor. The goal in all uses of the method is to provide for students a situation for learning that makes sense to them and can connect to what they know in a meaningful way. It does not disregard factual knowledge nor does it ignore the context in which the knowledge is learned. While engaging in the study of the case, students do not draw specific answers but instead say "this is what we know now" and continue to examine the issue. It helps them to experience issues and life situations from positions other than what they might encounter given their typical learning patterns. It gives students different perspectives on common problems and situations. Students come to appreciate a well-formed argument that may solve a problem and a good story that provides insight into an issue. The case approach allows students to examine issues that are not just interesting to their own curiosity but important for understanding the world in which they live.

Student Learning and Appeal

Student learning is the ultimate goal of any teaching. In order to use the case approach effectively there needs to be an understanding of the learning process and the impact cases can have on this process--on how students make sense (or non-sense) of new information (Inguarson and Finbert, 1992).

The pedagogic philosophy used in the case study approach is bound by the belief that learning is primarily a self-acquired process. Students are actively involved in the process by bringing their own experiences and interpretations as discussion points to a group of their peers. The case study approach is learner-centered in that it relies upon the experience of the student to collect, interpret, and explain the circumstances presented in the case. Learners are brought into the situation from their own particular framework of past experiences. Although learners may arrive at the same outcome and conclusion, the means by which they get there may be very different.

The way each person begins a task is dependent upon the level of various cognitive abilities. The way the information that is presented is processed depends on the organizational structure available in the individual patterning system of the brain. A person's interpretation of present events depends on prior experience. It is also affected by the sophistication of the processing abilities of the learner. Individual cognitive frameworks are formed by the ability to focus and attend to a task, to choose and analyze information pertinent to current problems, and to hold in memory distinct characteristics so they can be used appropriately in other situations. In order to process information so that it has meaning and transforms the way one acts in a certain situation, each learner must attend to and engage in the event at hand. This is what is meant by "learning by doing".

> Providing the experiential component as a base for learning, the case approach allows each individual to connect to the situation and "make meaning" of the event. A good case keeps the discussion grounded upon some of the stubborn facts that must be faced in real life situations. It is the anchor on academic flights of speculation. It is the record of complex situations that must be literally pulled apart and put together again before the situations can be understood.
>
> (Lawrence, 1953)

Using the case method, learners are presented the facts and the parameters of a particular event and asked to "mess around" with possible interpretations and investigative approaches to what is happening. Each learner will initially interpret the information differently. Prior knowledge may afford some students a good amount of factual information while others may connote positive or negative feelings about the issue. Personal interpretation of case studies requires the learner to be an analytic and complex thinker, focusing on the parts of the problem that have relevance for him/her. As each sorts through the information presented, decisions are made about what is important to remember and what can be discarded or set aside. The sorting process requires reasoned judgments about factual and experiential information ascertaining what is important and has meaning and what does not. Grappling with facts and feelings, students are drawn into the case and can identify it as something that is important to study. By discussing it with classmates they begin to understand how the same situation may be interpreted from differing perspectives. When students make a personal connection to the particulars of the case they become committed to investigating it in greater depth.

Research on learning styles indicates that people display preferences for ways of establishing meaning from the information presented. The traditional lecture approach to teaching appeals to those who learn best through auditory modes which comprise approximately 20% of all learners, leaving some 80% to figure out the presented task a different way.

A more complex and broader view of learning has emerged through the work of Howard Gardner on the theory of multiple intelligence (Gardner, 1983, 1993). This theory poses that the styles used by learners to process information may differ depending upon the task and the preferences of the learners. They may well exhibit one style of learning with one kind of information while exhibiting a contrasting style with other information. In this sense, learning

styles are not static but depend upon the circumstance of learning and the content presented. The case approach offers opportunities for all students to learn in a way that is most appropriate to the content and most conducive to their learning style, always active and inquiring.

Investigating issues through exciting cases develops in students a "whole set of skills of speaking, debating and resolving issues" (Erskine et al. 1981). When learners talk together about their individual experiences and interpretations of the case, they begin to realize the different perspectives and subsequent different paths that are possible for investigating the eventual solution. Ambiguity is tolerated and encouraged as it becomes clear that multiple interpretations are possible. Others are seen as resources in order to define the problem and investigate many possible solutions. Skills in oral communication are developed as they talk to one another about what they see and think. They learn to persuade, listen, understand, and convince others about certain points of view. They also learn the dynamics of learning as they accept, reject, and develop opinions.

> One interesting thing happens by the end of most case discussions; people begin to listen to each other, to think together, and to move toward a larger shared wisdom--'the community intelligence evolves.'
>
> (Hutchins, 1993)

Allowing groups to work on cases in non-traditional settings independent of an instructor, shifts the responsibility for investigating and arriving at conclusions to the students. It provides a "startled recognition of what a group of intelligent students can accomplish without a detailed dependence upon the professor's authority and knowledge" (Andrews, pg. 100-102).

Purpose of Case Study Approach to Learning

The purpose of the Case Study Method to enhance learning can be summarized in four points.

- This approach develops higher order thinking skills referred to in Bloom's taxonomy of cognitive learning. These include skills of analysis, synthesis, and evaluation associated with effective learning. Individual cognitive skills are nurtured as are abilities to establish and communicate points of view in a small group and publicly. Learning how to grapple with "messy" problems through the examination of cases requires development of analytical and decision-making skills, abilities in oral communication, and team building. This does not assume that students will neglect memorizing certain factual information. But it does assume that they will go further with the information--putting it back together in more interesting ways after they have examined the individual parts. It does not prevent students from knowing right and wrong answers to questions but they will be able to use the information which they get in order to make several decisions about the circumstance presented in the case.
- The case approach illustrates the relevance of the study in society. Students are able to connect the knowledge learned while doing the case study to current problems and issues. The description of the case gives students a context in which to ground the information they learn. They remember "the story" and hence the circumstances that go with the story. The situations that confront our lives do not easily fit into the models we have for examining them. We ask questions that indicate that the judgments we make are only valid given certain circumstances. Using cases to study issues allows students to apply theoretical

knowledge to real life situations where defining the situation clearly is absolutely necessary to understanding the findings.

- The learnings from a case approach are evident long after the study is finished. One of the purposes of education is to provide an informed citizenry in order that learners might contribute constructively to a broader more knowledgeable community. The outcomes of learning, then, need to extend beyond the context and time-frame provided in the classroom. The content must be relevant beyond that needed for a limited time. After completing a case, students can more critically appraise other stories they hear about issues related to the case. Because they have questioned, messed around with the data, and had to defend their conclusions to others, they are able to participate critically in public policy debates. They feel more a part of the broader public discussion because their experience has given them the skills to contribute constructively. They become better informed citizens.
- The case approach asks students to question assumptions underlying the theories presented. As students inquire about the reasons for certain happenings they discover the limits and gaps in the theories that are accepted as foundations for much of the thought about various issues. They learn quickly that assumptions must be delineated and terms must be defined in order to establish common understanding. No longer are theories taken as static and no longer do facts alone define theories. Which questions are asked, who asks them, and under what circumstance does have an affect on the answers found. No longer can the observer and the observed be separated. New theories are developed as existing ones do not answer the questions that are proposed.

The experience of investigating an issue through a case study helps the learner to "think like a practitioner" (Lachs, 1984). Reflection on the findings is integral to the practice. The theoretical melds into the practical. Students see themselves as researchers in the field working toward a solution as they would if they were in a position of employment within the area. They are scientists, lawyers, accountants, anthropologists, teachers for the period of the study. "It is a rehearsal for life."

The Case Study Approach in Science

Science concepts have been taught through cases where content information is presented in journal articles (Herried, 1994). The article is written in story format and subdivided into the organization of a scientific paper providing a literature source and description of how a scientist explores an issue using scientific reasoning. Sometimes the article is divided into introduction, materials and methods, discussion, and results. These cases are used for discussion purposes during the time of a class. What is missing from these scenarios is the student's experience with the scientific investigation. Where is the inquiry? Where is the hands-on experience? What is the grappling with "messy" problems? Where is the active learning called for in Project 2061's Science for All Americans (1989)? Where is the student as scientist?

This presentation will address reform efforts in scientific teaching and learning by providing a case study that includes both story telling and an accompanying laboratory. It was designed using a rubric of criteria that emerged from the literature on "case method" and scientific learning.

DESIGNING A CASE

CHARACTERISTICS	PARTICULAR CASE
Case Approach: Overall	
• Addresses a problem or the identification of a problem	The problem addressed in this case is...
• Presents new way of examining a situation - Integrates knowledge from several fields	The fields of knowledge represented here include...
• Demands high level thinking and communication skills - Categorize - Decision Making - Analysis - Evaluation - Reflection	The critical skills called for are...
• Develops Colleagueship - Tolerance for Others Ideas - Individual and Group Analysis - Multi-Perspectives	Collaborative efforts are encouraged through...
• Applies to "messy" real-life problems	The connection to real life problems is...
• Presents Results in Public Forum	The final project might be...

DESIGNING A SCIENTIFIC CASE

CHARACTERISTICS	PARTICULAR CASE
Case Approach: Science	
• Provides content knowledge in science area	At the end of this study, students will be able to use the following concepts:
• Uses scientific inquiry - Makes Hypotheses - Makes predictions - Observations and Experimentation - Analyses Data - Makes Evaluation - Draws Conclusion	At the end of this study, the students will "do" science by...
• Understands the Process of Science - What "is" science?	At the end of this study, students will understand...
Science Case Study: Specific	
• Represents kind of case - Dilemma Case - problem presented through one character, e.g. HIV positive patient - Issues Case - explores "what's going on here," e.g. Valdez oil spill - Case History - finished stories, e.g. Tuskeegee syphilis study	This study represents a _____ case because...
• Provides specific content objectives	Specific content objectives are...
• Uses format that matches purpose and content - Discussion - Debate, e.g. Nuclear energy must be part of energy production over the next 100 years - Scientific Research Team - divide into groups for parts of study - Problem-based learning	The best format to be used is _____ because...
• Structure of lab experience - Weekly/Flexible - On-campus - Off-campus - Supervised/Independent	The best way to integrate the lab experience is...
• Calls upon additional resources - Required readings - Content experts needed	The resources needed are...
• Demonstration of learning - Public hearing, e.g. student panel - Presentation in a public forum - Trial - Formal debate - Written case	The means of assessment that demonstrates the desired learning is _____ because...

The Moon Lake case is open-ended, inquiry based, multi-directional, interdisciplinary and contains a final project which is based in the community (Project 2061). It has student inquiry at the center, connecting content knowledge strands of several disciplines around a meaningful project. This case attempts to transcend even a multi-discipline method by looking at relevant issues through the lenses of a student/practitioner. It provides an approach to student learning that insists on both depth of knowledge and understanding of content and models what is known about how people learn and come to understand the world. It revolves around a theme and is tied to real world experiences. You will work collaboratively on this case. At the end of working with this case, students will:

- have practical experience in a scientific field
- understand the relevance of the material in a real-life context
- understand experimental design and scientific reasoning
- understand both "what science is" and "what a scientist does."
- Work with others collaboratively on a team
- Be able to present findings in a public forum

The goal of this presentation is to model for you learning by inquiry through the case method. It is a meaningful way to learn science as addressed in the reform efforts called for in Project 2061's Science for All Americans (1989):

- emphasis on critical thought
- recognition of the connections among ideas
- development of a vision of lasting knowledge and skills
- focus on science literacy

- construction through students' curiosity and creativity
- start with questions and phenomena that are interesting and familiar
- stress on group activity in the classroom
- emphasis on curricular connections

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Aquatic Ecology

A Case Study of Cultural Euthophication

Arthur Hessler

Background Information:

Ecology is usually defined as the study of the relationship of organisms with their environment. The key words here are **relationship**, the inter-relatedness of both the physical and biological worlds, and **environment**, the physical and biological conditions under which an organism lives. At the heart of the study of ecology today is the concept of an ecosystem, a defined area of study that encompasses both the living (biotic) and the non-living (abiotic).

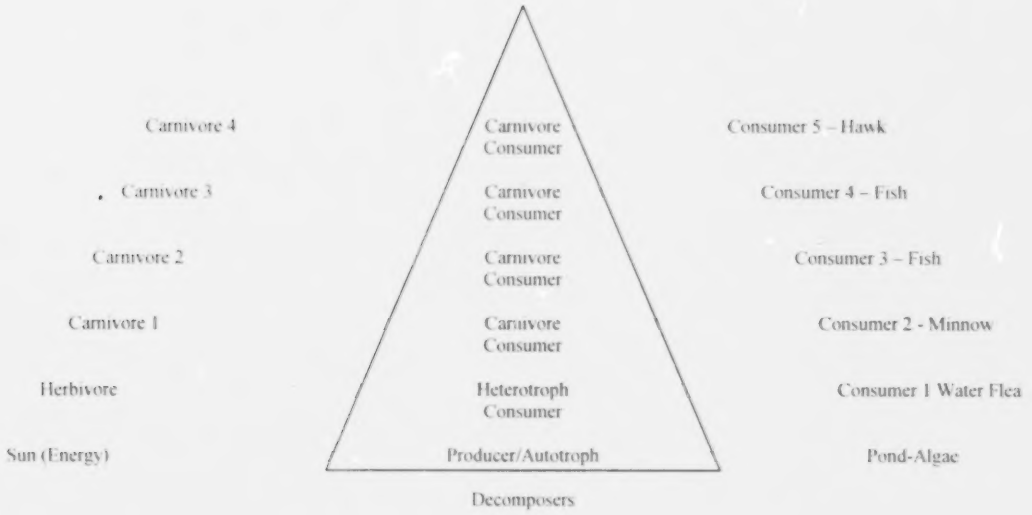
The concept of an ecosystem as a defined area of study, permits us to select a representative sample plot within a large tract such as the Easter Deciduous Forest or the Coniferous Forest for study. Communities are the biotic component of an ecosystem. They include all of the associated plant and animal populations within a defined area. A community is generally named for the dominant plant form – hemlock, oak-hickory, maple, grassland, shrub, and so on, life forms that do not move about as do the animals that are also there, but more transient visitors. In the area immediately adjacent to your home or school or this workshop site, there may be several different communities. Try to identify some of these; how large must the defined area be? How small may it be?

Aquatic ecosystems, such as a pond or a small lake, are different from terrestrial ecosystems in that they have well-defined boundaries – the shoreline, bottom, surface water – and can be studied both horizontally from the shoreline out and vertically from the surface down. Larger lakes and rivers or streams are more difficult to define, either due to their size or to the fact that the water is constantly changing with flow. They are usually subdivided by regions or sample-sites.

None of the ecosystems stand alone. For instance, a river ecosystem is directly affected by the terrestrial ecosystem(s) through which it flows. In all ecosystems, terrestrial or aquatic, there must be a constant input of energy from the sun. At the most basic level, including the sun as an energy source, each ecosystem must consist of four basic components: producer organisms or autotrophs; consumer organisms or heterotrophs; decomposers; and the non-living abiotic factors. The suffix trophy means to feed; the living members of an ecosystem, then, are identified by feeding levels. Autotrophs or producers are generally chlorophyll-containing green plants or algae that are able to convert the sun'' energy, and simple chemical compounds into food in the form of sugar. Food production by autotrophs is usually greatest at the surface of the ecosystem, either the canopy of the forest, the upper level of a grassland, or the surface water of a lake or pond. Heterotrophs are organisms that feed on living autotrophs and transform the energy of the autotroph into the energy that is necessary to sustain the heterotroph, maintain it or allow it to grow. Decomposers, in turn, feed on dead autotrophs and heterotrophs, reducing the complex materials in these organisms bodies to more simple chemical molecules to be recycled in the on-going ecosystem. Decomposer activity is greatest in the sediments of aquatic ecosystems and in the upper layer of the soil in terrestrial ecosystems. The fourth ecosystem component is the abiotic, which includes all that is non-living; inorganic, dead organic, CO_2 H_2O, O_2, various nutrients.

The four major feeding levels of an ecosystem are generally subdivided into a greater number, reflecting different feeding preferences. The inter-relationships between these feeding levels are identified as food chains or food webs. These are usually

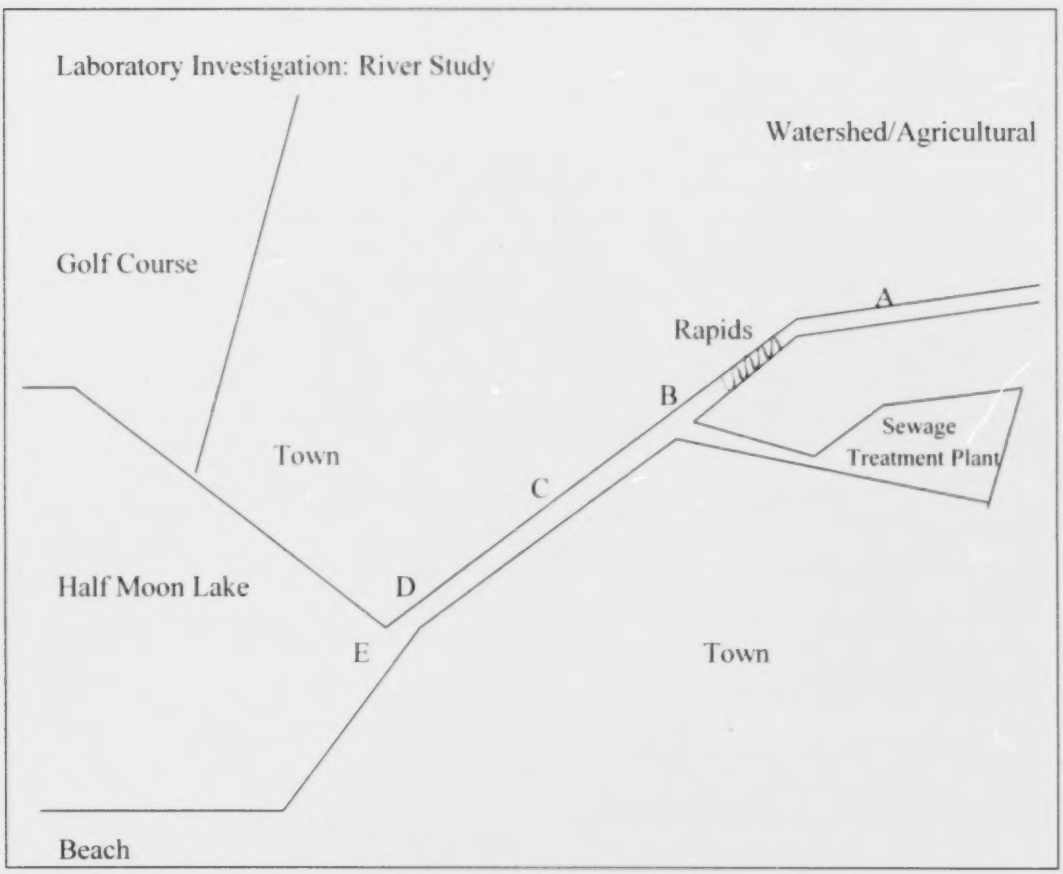
depicted in the manner in which energy flows through them and take the shape of an energy pyramid.



The pyramid shape of the food chain indicates that the energy level below (larger) must be greater than the next level, (smaller) i.e., more energy available in producers than in herbivores and so on. It also indicates that between each level, due to the inefficiency of energy transfer, much energy is lost, mostly as heat. A food chain, although easier to comprehend than a food web, is not representative of the feeding dynamics of an ecosystem. A food web incorporates many food chains and is more representative of the natural setting. Herbivores, in addition to the water flea, would include other insect larvae or nymphs, the first level of carnivores would include minnows of all sorts, and other insect larvae or nymphs, and so on.

Relevance: In a natural setting, food chains and webs are generally self-regulating and the general proportion of producers, consumers, decomposers, and abiotic factors is balanced. In our society today, however, there is often an artificial addition of

nutrients to the energy cycle at the producer level. Nutrients in the form of manure on fields and chemical fertilizers on lawns, golf courses and gardens are applied to increase production at the producer level (crops, grass…). Production by producers in an aquatic ecosystem is likewise enhanced by nutrients from storm sewers, run-off after a rain fall or snow melt, and from sewage from septic tank leach lines and sewage treatment plants. Many of these nutrients from whatever source, either directly or indirectly, find their way to ponds or lakes or rivers where their artificial enrichment causes algae (producer) blooms, choking vegetation and fish kills. This accelerated growth of algae and plants in the water is response to society's nutrients is called cultural eutrophication.



For the past several years, residents and others adjacent to Half Moon Lake noticed increased signs of eutrophication. During the summer months in particular, green slime is more prevalent on the rocks that line the shore, and rooted submerged plants are beginning to increase. The water is sometimes described as being "soupy." Periodically, especially in the morning, dead fish are seen floating on the surface, washed to shore. The water smells on occasion and last year the Board of Health posted the Lake as to "no swimming" for two weeks in July and two weeks in August. Half Moon Lake is about one mile long and one-half mile wide. Its deepest point is about 40 feet. It is fed by springs and the Fox River Watershed. There are several small outlet streams.

The Fox river is the primary source of water for Half Moon Lake. At point "A" on the River, we undertook an ecological assay in August and collected the following data:

Chemical Parameters

Nitrogen	low
Phosphates	low
Alkalinity	Moderate
Dissolved Oxygen	Relatively High
pH	Neutral
chloride	Low

Macroinvertebrates

Stoneflies	Several
Caddisflies	Abundant
Mayflies	Several
Crayfish	Several
Worms	None
Scuds	Some
Snails	Few
Clams	Some
Dragonfly Nymphs	Few

Assume that it is summer (August):

1. Consider the land use adjacent to the River and predict how and why the chemical and macroinvertebrate values might change as the Fox River flows through regions "B", "C", "D", and "E."
2. Based on your preceding observations, write a testable hypothesis that includes a "what is happening" statement, re: Half Moon Lake.
3. Write another testable hypothesis that includes a "why it is happening" statement, re: Half Moon Lake.

Continuing Projects:

1. Visit a sewage treatment plant that dumps effluent into a river. What type(s) of nutrient(s) is/are in the effluent? To where does the river carry the nutrients? Why should we be concerned about sewage treatment effluent?
2. Do a chemical analysis for phosphate and nitrate in the river water upstream and down stream from the effluent pipe of a sewage treatment plant. Is there a difference?
3. Collect and identify macroinvertebrates from the river upstream and downstream from the effluent pipe of the sewage treatment plant. Is there a difference? Most aquatic macroinvertebrates are herbivores (consumer 1).
4. Do phytoplankton counts of lake water sampled near the mouth of the river and from adjacent areas. Are plankton more prevalent in one or another area? Explain your results.